WIMIN 2025 - Abstracts of Student Talks

Morning Talks

Networks and Logic - McConnell B04

11:15 am - 11:30 am: Neural Dynamics of Word Segmentation

Speaker: Jayleen Jiang (Mount Holyoke College)

Abstract: Speech arrives as a continuous acoustic stream, yet listeners perceive it as a sequence of discrete words. This project investigates the neural dynamics underlying this process of word segmentation. Using EEG data and ERP analysis, we examined how distal speech rate affects the perception of acoustically reduced function words. We implemented a revised preprocessing and analysis pipeline to improve signal quality and recover ERP components such as the N1 and N280 across all participants and scalp regions. To complement this empirical analysis, we also developed a Bayesian model of perceptual inference that captures how listeners integrate distal rate information when segmenting speech.

11:35 am - 11:50 am: An expansion of multicolor forcing for concurrent input propagations

Speaker: Maddy Duncan (Mount Holyoke College)

Abstract: Trust, fault mitigation, and fault detection are common issues found in many different types of network-based systems. Previous literature has examined possible solutions to these issues by analyzing network controllability, perturbations, and general robustness against random failure. The conventional rules of zero forcing and multicolor forcing do not allow for simultaneous execution of rules, which does not adequately reflect the presence of concurrent signal propagation. In this paper, we seek to address these problems through an expansion of the field of multicolor forcing involving the modification of its rule and color sets. We outline a forcing network that simulates the simultaneous spread of two different classes of input signals that are competing to dominate the network. Beginning with the cycle family, we develop formulas that allow us to determine the probability of given outcomes in the termination state of graphs. We conclude by proposing some future directions for research and possible applications of our results.

11:55 am - 12:10 pm: Classifying Panic Attack Frequency: A Comparison of Logistic Regression and Neural Networks

Speaker: Ranee James (Eastern Connecticut State

Abstract: Approximately 23% of U.S. adults experience at least one panic attack during their lifetime, while 2.7% meet criteria for panic disorder in a given year, with lifetime prevalence reaching 4.7%. Panic disorder is associated with significant impairment and burden. While individual risk factors are well documented, most research has focused on single predictors or short-term forecasting, with limited attention to how diverse factors interact to classify individuals by panic attack frequency. Using an unverified open-source dataset, this study applies statistical and machine learning methods to investigate whether a combination of demographic information, physiological symptoms, medical history, panic-specific features, and behavioral factors can predict high- and low-frequency groups. Two predictive models were implemented and compared: logistic regression and a neural network. The best-performing neural network achieved an accuracy of 67.5%, compared to 61.2% for logistic regression. Both models identified variables most strongly associated with high panic attack frequency, underscoring the importance of considering multiple interacting factors. These results demonstrate the potential of predictive modeling in mental health research and lay the groundwork for future studies using validated clinical data.

Applied Math I - McConnell B10

11:15 am - 11:30 am: Modeling Deformable Bacteria in Flow

Speaker: Abigail Drumm (Worcester Polytechnic Institute)

Abstract: Acholeplasma laidlawii is a bacterium that lacks a cell wall and thus exhibits considerable deformability. During the course of membrane filtration, it has been observed penetrating through pores that are much smaller in radius than itself. We present current investigations into modeling the movement of this bacterium into and through a narrow pore.

11:35 am - 11:50 am: FitzHugh-Nagumo System with Deterministic and Stochastic Disturbances

Speaker: Jayson Ruml (Mount Holyoke College)

Abstract: Systems modeled using differential equations often include a continuous disturbance. In reality, disturbances usually occur at discrete times, and include some randomness. To what extent do the predictions of these continuous models still hold when the disturbance is instead applied at discrete time intervals? Moreover, what if the disturbances, and the times between them, are randomly distributed? This project investigates solution behavior of the FitzHugh-Nagumo system of differential equations with both deterministic and stochastic flow-kick disturbances. We use simulation, numerical approximation, and MatContM continuation to find bifurcations and study solution behavior.

11:55 am - 12:10 pm: Drug Resistant TB in the US

Speaker: Isabella Delmonte (Mount Holyoke College), Phoebe Huang (Mount Holyoke College), Myat Kyaw (Mount Holyoke College)

Abstract: Tuberculosis (TB) remains a major public health challenge in the United States, with drug-resistant strains such as isoniazid-resistant, rifampin-resistant, and multidrug-resistant TB complicating treatment and control. This project develops a compartmental differential equation model to capture the dynamics of multiple TB strains and uses a genetic algorithm to estimate 27 key parameters. Model outputs are compared with CDC surveillance data from 1993–2023 to evaluate accuracy and identify challenges in fitting high-dimensional systems. Preliminary results show partial alignment with observed trends, while highlighting the difficulty of parameter estimation. Ongoing work focuses on refining the genetic algorithm and incorporating additional resistance categories and data sources, with the goal of producing updated insights into drug-resistant TB dynamics and informing public health strategies.

Mathematical Physics - McConnell 102

11:15 am - 11:30 am: Trajectories in Two Worlds: An Introduction to Classical & Quantum Dynamics

Speaker: Reyna Li (Williams College)

Abstract: How do particles move? In classical physics, particles follow smooth, predictable trajectories. But in quantum mechanics, the math is stranger: particles don't follow clear paths. In this talk, I will begin by discussing classical and quantum mechanics before describing the quantization process that connects the two. I will then compare and contrast classical and quantum trajectories in two settings: the torus and the complex projective line. Along the way, I will provide many diagrams and visuals. No physics background will be assumed.

11:35 am - 11:50 am: An Optimal Control Approach to Modeling Binocular Vision

Speaker: Liza Platonov (Middlebury College)

Abstract: We present an optimal control framework for binocular trajectory tracking, contributing to a 170-year-old body of literature on mathematically modeling binocular gaze. We model each eye as a spherical rigid body rotating according to physiological constraints that limit the rotation to a two-dimensional submanifold of SO(3). Using Euler-Lagrange and Hamilton's equations of motion, we derive a system of coupled, non-linear, second-order differential equations. These equations govern the rotational dynamics of the eyes such that the muscle-induced external torques are minimized while tracking an object with a known trajectory. This allows us to formulate the rotation of the eyes as a two-point boundary value problem. We further explore a variation of the problem in which the eyes follow an object with an unknown trajectory.

11:55 am - 12:10 pm: Aspects of matrix Lie groups with a view toward spinors

Speaker: Angela Barrett (Northeastern University)

Abstract: This project investigates the intricate relationships between various matrix Lie groups and their corresponding Lie algebras, in particular from the point of view of quaternionic representations, with the goal of gaining insights into spinors and their geometric and algebraic foundations. The project takes a ground up approach, going through a development of foundational Lie theory to work through the various facets of relationships between low-dimensional matrix Lie groups. The culmination of this inquiry is an introduction to spinors, exploring how the previously developed algebraic and geometric insights over a pathway to understanding spinor representations. This systematic approach illuminates the foundational connections between matrix Lie groups, Lie algebras, and spinor theory.

AI and Machine Learning - McConnell 103

11:15 am - 11:30 am: Geometry of Compositional Abstraction in Large Language Models

Speaker: Salma Ziadi (Mount Holyoke College)

Abstract: This talk investigates the geometry of compositional abstraction in large language models (LLMs) by examining how algorithmic primitives are represented and combined within model hidden states. We focus on two reasoning domains: graph navigation and the Traveling Salesman Problem (TSP). In the graph navigation task, we identified core primitives, operationalizing them as function vectors (FVs) derived from model activations. By composing these FVs through vector addition and injecting them into intermediate layers, we assessed their capacity to steer LLaMA-3-8B toward correct reasoning. Results demonstrate that combined FVs enhance accuracy beyond individual primitive interventions, indicating that compositional representations can be manipulated to improve reasoning robustness. In the TSP domain, we analyzed verification primitives and hidden-state trajectories in Phi-4 and Phi-4-Reasoning, using t-SNE to reveal differences in representational stability and distance sensitivity. Phi-4-Reasoning exhibits more distinct and consistent verification token trajectories, compared to Phi-4. Our findings suggest that understanding and manipulating the geometric structure of primitives in LLMs provides a principled approach to probing and improving multi- step reasoning capabilities across tasks.

11:35 am - 11:50 pm: Efficient and Interpretable Modeling for High Dimensional Data

Speaker: Grace Nelson (Mount Holyoke College)

Abstract: High dimensional data are large datasets with many features, and sometimes more features than observations. This can create an issue for most traditional regression models, as some of the assumptions of those models are violated, and the data introduces issues to consider such as multicollinearity, dangers of overfitting, and more.

To have an accurate prediction model, other more complicated regression models and deep learning models are considered. Deep learning models, such as neural networks, while powerful, are an uninterpretable black box, meaning that results cannot be described in terms of variables having more or less of an impact on the response. Regression models, such as LASSO and SCAD, may be less powerful and efficient than a neural network, but have interpretable results, which are important for understanding relationships within data. In this project, the tradeoff between interpretability, efficiency, and accuracy will be investigated through the comparison of different models .

Discrete Math and Combinatorics - McConnell 104

11:15 am - 11:30 am: Patterns in Rectangulations

Speaker: Michaela Polley (Dartmouth College)

Abstract: Given a rectangle, how many ways can we break it up into smaller rectangles such that we never have four rectangles sharing a corner? What about if we further require all vertical lines to meet the top of the rectangle? These questions can be answered by studying objects called rectangulations. In this talk I will give a gentle introduction to rectangulations, pattern avoidance, and more generally to the sorts of questions that we think about in combinatorics (i.e. the math of counting and patterns). I will also highlight connections to inversion sequences and Dyck paths. This talk assumes no prior knowledge in combinatorics.

11:35 am - 11:50 am: Discrete Calculus and Its Applications

Speaker: Caylee Spivey (University of Connecticut)

Abstract: In this talk, we will develop an analogue of ordinary calculus for sequences instead of functions. Our main tool: finite differences. Using this tool, we will prove discrete analogues of many theorems including the Fundamental Theorem of Calculus. Finally, we will apply our newly developed techniques to find "nice" formulas for common partial sum expressions.

11:55 am - 12:10 pm: Quads: Shapes and Daily Puzzle

Speaker: Yumo Liu (Bard College)

Abstract: In the card game Quads, players look for collections of four cards satisfying a particular pattern, called *quads*. We explore the question of how many quads there can be in a fixed number of cards, and what that means for the Quads Daily Puzzle.

Number Theory - McConnell 403

11:15 am - 11:30 am: Algorithms for Complementary Sequences

Speaker: Araceli Friedman-Pitt (Smith College), Meredith Williams (Smith College)

Abstract: We analyze properties of complementary sequences which together make up the natural numbers. Specifically, we focus on Beatty sequences which are generated by taking the floor of subsequent multiples of a given irrational number. Using the previously established MES algorithm, we identify a relation between specific irrationals and MES parameters in which input and output sequences of the algorithm have the same slope. Finally, we identify patterns present among the resulting sequences, particularly when those sequences can be defined explicitly.

11:35 am - 11:50 am: Evidence for the Missing Prime: Numerical Semigroups and Semiring Quotients

Speaker: Jay Chen (Vassar College), Harriet Simons (Vassar College)

Abstract: Evidence for the Missing Prime: Numerical Semigroups and Semiring Quotients

The concept of the missing prime has been a guiding analogy for the development of number theory for more than a century. In this project, we pursue two new threads in the hunt for the missing prime: numerical semigroups and semiring quotients. With this motivation in mind, we define a new product operation on numerical semigroups and use it to classify a new family of symmetric numerical semigroups. We also generalize the concept of numerical semigroups from the natural numbers to more general semirings, including totally positive quadratic integers. We extend fundamental results and concepts from the classical theory of numerical semigroups to this new setting. With semiring quotients, we find a more direct connection with the missing prime for natural numbers via unique factorization of congruences. Extending this to totally positive quadratic integers presents new and interesting challenges. We prove several structural results about congruences in these semirings, including their finite generation.

11:55 am - 12:10 pm: Arithmetic Sequences and Repdigits

Speaker: Runtong Zhang (Mount Holyoke College)

Abstract: The Berkeley Math Circle Competition (Contest 7, 23 April 2000) poses the following problem: Prove that there are infinitely many terms in the arithmetic sequence 8, 21, 34, 47, ... which consist entirely of nines. An n-digit repdigit is apositive integer of the form rr...r denoted rn where r is a nonzero digit.The objective of this project and talk is to characterize those arithmetic sequences that have no repdigits, a finite number of repdigits, and an infinite number of repdigit.

Analysis and Geometry - McConnell 404

11:15 am - 11:30 am: Extensions of Buffon's Needle Problem Using the n-Stick Star

Speaker: Isabel Mikheev (Williams College, Geisel School of Medicine)

Abstract: In 1777, Georges-Louis Leclerc, Comte de Buffon introduced one of the earliest problems in geometric probability. Consider randomly tossing a needle of unit length onto a plane ruled by the lines y = n (n = 0, ±1, ±2, ...). The probability that the needle intersects some line, given no preference for position or direction, is $\frac{2}{\pi}$. If we consider two of these needles and join them perpendicularly at their midpoints (we call this a "cross"), then the expected number of intersections of the cross and the plane of parallel lines is $\frac{4}{\pi}$. In this talk, we will explore more complex configurations such as the three-stick star and four-stick star, and then generalize our findings to the n-stick star, a group of n needles joined at their centers and spaced at equal angular intervals. We will derive a closed-form expression for the expected number of intersections of the n-stick star and the variance of this estimator for $\frac{2}{\pi}$., and prove that this variance decreases and converges as n approaches infinity. Finally, we will extend this problem to the continuous limit of this construction as the n-stick star approaches a disc, and compute the expected proportion of the disc that will cross the line.

11:35 am - 11:50 am: Time-Uniform Limit theorem for Markov Chains

Speaker: Xizhi Zhou (Mount Holyoke College)

Abstract: My research at MHC this summer focuses on the time-uniform convergence properties of perturbed discrete-time Markov chains. We consider chains whose transition probabilities depend on a small noise parameter and investigate the limiting behavior as both the noise level decreases and time grows. While existing results describe limiting distributions at specific time scales, they do not provide uniform control across all times.

11:55 am - 12:10 pm: Singular Curves and Metric Lines in 2-Jet Space

Speaker:] Dani Catalá (MIT), Miriam Vollmayr-Lee (Grinnell College)

Abstract: A geodesic is the shortest path between two points, and understanding when such a path is globally minimizing is a central question in differential geometry. We call globally minimizing geodesics metric lines. In 2024, A. Bravo-Doddoli, E. Le Donne, and N. Paddeu. showed that there exists a bijection between geodesics in the jet space and algebraic curves arising from degree two polynomial vectors. In this talk, we introduce these algebraic curves. We classify curves with singularities that are in bijection with metric lines in the jet space. Central to our work is the period map, which encodes the asymptotic behavior of these geodesics. We show the period map is one-to-one by applying Hadamard's global diffeomorphism theorem.

Afternoon Talks

Applied Math II - McConnell B10

2:30 pm - 2:45 pm: Trade Policy Uncertainty and Exchange Rate Volatility: Evidence from the 2025 U.S.-China Tariff Announcement

Speaker: Melissa Wang (College of the Holy Cross)

Abstract: This research examines the responsiveness of short-term exchange rate dynamics to abrupt changes in trade policy, focusing on the USD/CNY pair in the aftermath of the U.S. government's tariff announcement on March 3, 2025. Leveraging daily exchange rate data and applying an AR(1)-GARCH(1,1) specification, the study uncovers a notable surge in conditional volatility—approximately 60% higher compared to levels preceding the announcement. Diagnostic results reveal clear signs of volatility clustering, stationarity, and notable ARCH effects, supporting the suitability of employing the GARCH model to reflect uncertainty driven by geopolitical events. Although definitive causal inference is beyond the scope of the model, the temporal proximity between the policy shock and the volatility escalation indicates heightened investor sensitivity to trade-related news. Robustness checks using alternative GARCH structures reinforce the reliability of the findings. The paper also suggests avenues for further investigation, including the incorporation of asymmetric volatility components and the extension to multivariate settings. These insights highlight the crucial role of consistent and transparent policy communication in stabilizing investor expectations and underscore the importance of incorporating event-driven risk factors into financial risk management strategies.

2:50 pm - 3:05 pm: V-line Tomography: Principles and Reconstructions

Speaker: Olivia Hwang (Smith College)

Abstract: Ever wondered how CT or X-ray image reconstruction works? Come and hear about the mathematical principles that make these tomographic imaging methods work, and the characteristics of image reconstructions from limited data in optical V-line tomography. This talk will go into general tomographic principles, tomographic modeling with Beer's law, and findings about the internal angle of V-lines, artifacts from limited data, and reconstructions of interesting objects.

3:10 pm - 3:25 pm: Investigating the Role of Gap Junctions in Transitions between Bursting and Tonic Firing

Speaker: Halimatou Dieye (Middlebury College)

Abstract: Synchronization is a widespread phenomenon in neuronal systems, linked to conditions such as epilepsy and Parkinson's disease. Better understanding of the properties of neuron synchronization is key to both advancing theory and developing targeted cures for these disorders. Part of this comprehension includes studying gap junctions, well-known neuronal structures that facilitate communication between adjacent neurons. Coupling neurons with gap junctions often increases synchronization; however, the degree of synchronization may depend upon the individual neuron's firing pattern. In this work, we focus on neurons that transition between tonic and bursting firing regimes and investigate the effect of coupling such neurons with a gap junction. We find that coupling neurons in the same firing regime leads to synchronized firing of both neurons within that regime. The interesting cases lie in coupling neurons in different regimes, one bursting and one tonic, in which we find that the embedment of the neuron within their regime influences the resulting firing pattern. In this talk, we highlight the biological mechanisms underlying the observed transitions between the synchronization regimes as the gap junction coupling strength increases.

Statistics - McConnell 102

2:30 pm - 2:45 pm: Analysis of Player-Elimination Tournaments

Speaker: Emily Rosaci (Smith College), Rya Jasmin Donelo (Smith College)

Abstract: In a player-elimination tournament, multiple players compete against each other in several rounds. After each round, the lowest-performing players are eliminated, leaving the rest to battle it out until a single player remains. We are certain that the reader can imagine many examples of a player-elimination tournament - from horse racing, to eSports, to reality TV shows like Survivor or American Idol - and we expect more to come due to their popularity in media and entertainment. However, despite the prevalence of these tournaments, there are few studies that seek to model these types of competitions. As such, we begin to investigate a model that will not just make predictions to determine the tournament winner, but will predict the outcome of each contestant at the end of a round. In order to analyze these round-based tournaments, we gathered data from the 2004 television series Project Runway, and evaluated two types of models. The first is a multinomial logistic regression model which integrates splines based on contestant demographics such as age, gender identity, and past performance in previous episodes. The model also uses stratified cross-validation which holds out either an episode or season and then applies a softmax function to convert log-odd scores to probabilities. With these probabilities we are then able to determine which contestants are most likely to win each episode. Additionally, we are in the process of applying a proportional odds logistic regression model that also learns as the tournament progresses. With this model, we are looking to incorporate tiered outcomes that not only predict episode winners, but is able to determine which contestants are likely to be the highest or lowest performers.

2:50 pm - 3:05 pm: Comparing Federal and Community Level Air Quality Data in Baltimore

Speaker: Cynthia Arguijo (Smith College)

Abstract: During my summer internship at the Smithsonian Environmental Research Center, I supported Breathe Baltimore, a community led pilot project that aims to provide access to air quality data and low cost sensors. Using linear regression analysis and the Spearman rank correlation test, I compared the air quality data from seven of the Breathe Baltimore sensors to that of the only federal EPA air quality sensor in Baltimore. Although the EPA sensor is located far from both Downtown Baltimore and the industrial facilities of South Baltimore, it is often used to be representative of the entire city's air quality. Using statistical analyses and spatial visualizations, my project investigated how exactly the data from both types of sensors differ for two air pollutants: particulate matter 2.5 and ozone.

3:10 pm - 3:25 pm: Parameter Estimation for the Logistic Regression under Case-Control Studies with Measurement Error in Covariates

Speaker: Chameli Piyatilake (University of New Hampshire)

Abstract: Logistic regression is a widely used statistical method for analyzing binary outcomes, particularly within case–control study designs in epidemiology and biostatistics. A major challenge in such studies arises when covariates are measured with error, leading to biased and inconsistent parameter estimates if not properly accounted for. This presentation introduces a validation-based method for estimating logistic regression parameters when covariates are subject to classical measurement error. Building on the integrated square distance (ISD) framework proposed by Geng and Sakhanenko (2016), the proposed estimator uses a small validation subsample to nonparametrically adjust for bias via kernel-based density estimation. The method is compared against three benchmark estimators, including the naive ISD, contaminated-data MLE, and the Stefanski–Carroll bias-corrected MLE. Simulation studies under Gaussian and Exponential covariate distributions demonstrate that the proposed method consistently reduces bias, especially in small samples or under large measurement error. The results highlight the benefits of incorporating modest validation data to improve inference in logistic regression models with covariate uncertainty.

Education and Social Justice - McConnell 103

2:30 pm - 2:45 pm: Centering Belonging, Identity and Self-Efficacy in Introductory Calculus

Speaker: Gemma Qu (Smith College), Alice Dai (Smith College), Helen Zhou (Smith College)

Abstract: For many students entering college, Calculus remains more of a filter than a pump. This research presents a case study of a reformed, inclusive, student-centered Calculus program at a women's liberal arts institution that employs ambitious educational methods. Grounded in the Mathematical Association of America's (MAA) Seven Characteristics of Successful Calculus Programs, the Calculus program integrates active learning, coordination, revision, reflection, and innovative assessments, and has shown strong positive outcomes from students. We describe key instructional characteristics and provide a mixed-method analysis of students' affective experiences, with focus on students from traditionally marginalized groups. In particular, we examine constructs such as math identity, sense of belonging, and self-efficacy, highlighting how instructional practices influence students outcomes Our findings reveal diverse student experiences shaped by identity and background, and highlight the importance of intentional practices and support structures in creating more equitable and affirming calculus classrooms.

2:50 pm - 3:05 pm: Prison Gerrymandering in Mississippi and Wisconsin: A Redistricting Comparison

Speaker: Kiara Fontes (College of the Holy Cross)

Abstract: Prison gerrymandering, which counts incarcerated individuals as residents of their prison location rather than their home communities, can significantly distort political representation. This study uses a redistricting algorithm to examine how this practice affects state legislative districting and minority representation. We applied the Recombination method to generate 10,000 alternative state senate district plans for both Mississippi and Wisconsin. Districts were simulated under three population regimes: (1) unadjusted Census data, (2) population data with incarcerated people reallocated to their home communities, and (3) population counts excluding incarcerated individuals entirely. By comparing ensembles across these regimes, we analyzed how redistricting outcomes and minority representation shift under different population counts. This approach enables a quantitative comparison between current districts and those reflecting more accurate residency counts. The analysis explores how prison gerrymandering affects redistricting outcomes, minority representation, and partisan bias. By simulating maps under alternative population-counting schemes, this research informs broader debates on redistricting fairness and supports evidence-based policy reform.

3:10 pm - 3:25 pm: Gender, Math Anxiety, and Expressive Writing: A Developmental Text-Analytics Study from K–12 to College

Speaker: Yiru Wang (Mount Holyoke College), Ruobing Zhou (Mount Holyoke College)

Abstract: Mathematics anxiety taxes working memory and can hinder performance; a 5-minute pre-exam expressive-writing prompt has been proposed to offload anxiety via emotional processing in laboratory settings. We report a quasi-experimental study in Chinese Grades 6-8 (N = 359), with classes assigned to expressive-writing or neutral prompts across two regular exams. Mixed-effects models replicated a robust anxiety–performance association ($r \approx -0.48$), while the Time × Condition term was not significant, indicating no detectable average gain from a single brief session in an authentic K–12 classroom setting. Exploratory mediation suggested an indirect gender → anxiety → performance pathway (95% CI [0.054, 0.211]) with non-significant direct/total effects.

To interpret the null finding, we triangulated with interpretable text analytics (LIWC & NLTK) to compare K–12 and US college samples. College writers showed dramatically different linguistic patterns: doubled authentic emotional expression (83% vs. 43%, $d = 1.4$), nearly twice the sentence length (18 vs. 11 words, $d = 1.19$), and stronger linguistic separation by anxiety level, consistent with a developmental account of cognitive-emotional readiness for expressive writing. We conclude that the effectiveness of expressive writing likely depends on cognitive-developmental stage and discourse norms, clarifying boundary conditions for when—and for whom—it supports math learning. Our work illustrates the feasibility of turning classroom text into interpretable indicators in a reproducible, privacy-aware manner, and discusses implications for equity-focused, data-informed practice.

Graph Theory - McConnell 104

2:30 pm - 2:45 pm: Reduced Trip Permutaions of Plabic Graphs

Speaker: Gemma Bertain (Smith College)

Abstract: The decorated trip permutation of a reduced plabic graph tells us what cell in the Grassmannian the graph parameterizes. We study the trip permutations of unreduced plabic graphs and how they change when the graphs are reduced. If the output is a permutation with no fixed points, this tells us what cell in the Grassmannian an unreduced graph parameterizes without actually reducing the graph.

2:50 pm - 3:05 pm: Minimum Tree Covers and Forbidden Edges of Graphs

Speaker: Gráinne Beltramo-Dolan (Mount Holyoke College)

Abstract: The study of tree covers of graphs is relatively recent, and most prior work has focused on the tree cover number. In this project, we studied ways to count the number of minimum tree covers of graphs, investigated "forbidden" edges in graphs which appear in no minimum tree cover, and sought to learn about graphs with the minimum and maximum possible numbers of minimum tree covers. We introduced a new graph parameter and found formulas to compute it for certain families of graphs, and we discovered patterns in graphs that reach its minimum and maximum values.

3:10 pm - 3:25 pm: Community Detection on Directed Networks through Normalized Ricci Flow

Speaker: Oluwadamilola Oguntuyo (College of the Holy Cross)

Abstract: Using discrete Ricci curvature as a geometric tool for detecting communities in complex networks is a growing area of study. Lin-Lu-Yau curvature, a variation of discrete Ricci curvature based on Ollivier Ricci curvature, quantifies how well connected two nodes are within their local neighborhoods. Using the weights of the graph's edges and by calculating the Wasserstein distance from each node to another, we can calculate the Lin-Lu-Yau curvature of the network. We implement a normalized discrete Ricci flow, updating the weights of the edges based on the curvature. After iteratively computing the Ricci flow, we perform a surgery removing all edges with weights above a certain threshold. The best threshold is found by maximizing modularity, which allows us to identify communities within the network. We implement these methods on directed networks, after adapting the curvature computations to account for the asymmetry of the edges. We focus on detecting flow-based clusters, which are groups of nodes where a random walk is more likely to remain contained. By analyzing these clusters, we gain insights into the network's structure and how information or probability mass flows within it. By extending discrete Ricci curvature and normalized Ricci flow methods to directed networks, this approach offers a powerful framework applicable to diverse fields such as communication systems or social network analysis, enabling a deeper understanding of complex network structures.

Algebra - McConnell 403

2:30 pm - 2:45 pm: Dynamical Irreducibility of Polynomials over Finite Fields

Speaker: Tram Nguyen (Mount Holyoke College), Minh Le (Mount Holyoke College)

Abstract: Let $\mathbb{F}_p$ be a finite field and $f(x)$ is in $\mathbb{F}_p[x]$ with degree at least 2. A polynomial f is dynamically irreducible if the nth iterate $f^n(x)$ is irreducible for all positive integers n over $\mathbb{F}_p[x]$. Dynamical irreducibility of polynomials over finite fields is an active area of research in arithmetic dynamics which is a subfield of number theory, dynamical systems and abstract algebra. In this talk, we will discuss our methods for investigating the dynamical irreducibility of cubics and quartics over finite fields modulo primes, specifically using algorithms implemented in Magma and data visualizations in Python.

2:50 pm - 3:05 pm: Left and Right Quotient Sets in Non-Abelian Groups

Speaker: Ava Kennon (Amherst College)

Abstract: For a group G, we define the right quotient set and the left quotient set as follows

$$AA^{-1} := \{a_1 a_2^{-1} : a_1, a_2 \in A\},$$

$$A^{-1}A := \{a_1^{-1} a_2 : a_1, a_2 \in A\}.$$

We examine the relationships between the left and right quotient sets. If G is an abelian group, then these sets are equal, but subtleties arise in non-abelian settings, as these sets may not have the same cardinality. Tao remarked that the cardinality difference $|AA^{-1}| - |A^{-1}A|$ may be arbitrarily large for certain groups.

We first give explicit constructions of sets A where this difference attains every possible integer, proving that the difference can be any possible value if G has elements of order 2.

We also find the minimum cardinality of A so that the difference between the cardinalities of the left and right quotient sets is nonzero, depending on the existence of order 2 elements in G.

To prove these results, we construct a graph called the difference graph D_A that encodes equality in the right quotient set. Similarly, $D_{A^{-1}}$ encodes equality in the left quotient set. By observing an isomorphism of edges in D_A and $D_{A^{-1}}$ and counting connected components, we are able to prove the results above. In the free group on two generators, we can prove that the difference $|AA^{-1}| - |A^{-1}A|$ is always even. We explicitly construct subsets of F_2 that achieve every even integer. In the infinite dihedral group $D_\infty \cong \mathbb{Z} \rtimes \mathbb{Z}/2$, we prove that every integer difference is achievable, using the results of Martin and O'Bryant on the cardinality differences of sum sets and difference sets.

3:10 pm - 3:25 pm: Minimal Chiral Polyhedra

Speaker: Evan Angelone (Northeastern University)

Abstract: An abstract chiral polyhedron is a certain rank 3 poset for which the group of incidence-preserving bijections of that poset induces exactly two orbits on the flags, and does so in such a way that two adjacent flags lie in distinct orbits. There is a covering relation among these polyhedra which gives the collection of chiral polyhedra a lattice structure under this relation. We use the minimal polyhedra in this covering lattice to give a partial classification of the groups of chiral polyhedra of order $2^k p$. Specifically, we characterize the minimal chiral polyhedra of type $\{2^s, 2^t\}$ with $2^k p$ flags where $p \equiv 1 \pmod{2^k}$. This gives insights into a general construction of chiral polyhedra from the affine group $\mathrm{AGL}(1, p^n)$ where $n \geq 1$.

Analysis on Polytopes and Signals - McConnell 404

2:30 pm - 2:45 pm: Signal Recovery Using Gowers' Norms

Speaker: Iana Vranesko (Williams College)

Abstract: When transmitting signals, we often send the Fourier transform instead of the raw signal, as it's usually more convenient and efficient. However, often the channel is noisy, causing some of the frequencies to be unobservable and preventing accurate reconstruction. Recently Iosevich and Mayeli analyzed the sparse, finite, binary case with signal $f : \mathbb{Z}_N^d \to \{0, 1\}$, $\hat{f}$ suitably normalized, and $S \subset \mathbb{Z}_N^d$ the set of unobserved frequencies. They prove many recovery estimates that ensure exact recovery after applying simple rounding algorithms. Specifically, they use restriction theory to show that if the additive energy

$$|\{(x, y, x', y') \in U^4 : x + y = x' + y'\}|$$

is sufficiently small for every $U \subset S$, then f can be recovered exactly.

We extend the use of additive energy to higher-order Gowers norms, a powerful framework from additive combinatorics that captures increasingly subtle arithmetic structure. Notably, the second Gowers norm coincides with additive energy, while higher norms generalize this by detecting longer arithmetic patterns. Using this approach, we significantly strengthen the additive uncertainty principle in the finite setting, yielding sharper recovery guarantees even in the presence of more adversarial frequency loss. Our new conditions ensure exact reconstruction under broader circumstances than previously known. Ongoing work focuses on fully characterizing the role of higher Gowers norms in signal recovery, with the goal of developing robust, structure-sensitive criteria for signal reconstruction in noisy or incomplete frequency regimes.

2:50 pm - 3:05 pm: Circle configurations from regular skeletal polyhedra

Speaker: Jieying Jin (Northeastern University)

Abstract: In this talk, I will discuss how circle configurations can be constructed from regular skeletal polyhedra. We will begin by examining the structure of regular skeletal polyhedra, focusing on their fundamental properties and how they serve as a basis for constructing more complex configurations. I will first introduce the E-construction method, and then present a basic example to illustrate how the edges of a polyhedron are transformed into structured geometric configurations. Finally, I will delve into the resulting circle configurations. This presentation aims to bridge the understanding of polyhedral structures and their connection to circle configurations, offering insights into the broader implications of these constructions. This is joint work with Egon Schulte.

3:10 pm - 3:25 pm: Researching Perfect Quantum State Transfer of One-Dimensional Quantum Chain

Speaker: Jasmin Enriquez (University of Hartford)

Abstract: